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Microwave Landing System (MLS) Multiple System Design Interoperability Interface Control Report

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June 1989

Final Report

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16. Abstract This document standardizes the communications interface between two Microwave Landing Systems one each installed at opposite runway ends and which are each of a different design/manufacture. The interface requirements include the physical, data link control and application level requirements and are established to promote the interoperability of the systems. Functions specified include the establishment and termination of transmissions, and the structure, format, and encoding of messages and commands for transmission. The logical units and datapoints for all Microwave Landing System monitored parameters and status parameters are addressed. Additionally, a synchronization function is established to provide a timing reference to assure interference free transmission of the signals-in-space from each of the two MLSSs. The operation, encoding and format of the synchronization function is provided.					
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LIST OF ABBREVIATIONS

AZ	MLS Azimuth equipment
bps	Bit Per Second
dBm	Decibel referenced to one milliwatt
DME/P	Precision Distance Measuring Equipment
EL	MLS Elevation equipment
MLS	Microwave Landing System
ms	Millisecond
mW	Milliwatt
ns	Nanosecond
nW	Nanowatt
RCSU	Remote Control and Status Unit
REU	Remote Control and Status Electronics Unit
RMS	Remote Monitoring System
RSU	Remote Status Unit
SDR	Site Data Report
TWA	Two Way Alternate
TWS	Two Way Simultaneous
us	Microsecond
UN	Unbalanced configuration, Normal response mode
uW	Microwatt

1. INTRODUCTION.

This report identifies the interface criteria which will enable two Microwave Landing Systems (MLS), which have been produced by different manufacturers, to operate together when one is located at one end of the runway and the other is located at the other end. It promotes, for the implementation of this interface, the approach and conventions for data link protocols and data formats of NAS-MD-790 as tailored by DOT/FAA/PS-89/2 for the application of the MLS to the Remote Monitoring Subsystem and Remote Maintenance Monitoring System (RMMS) interface. It also defines the physical transmission requirements for implementing the interface. Microwave Landing Systems of differing designs which are based on FAA-E-2721 shall interoperate on the same runway via the interface defined herein.

1.1 System interface overview. FAA-E-2721 specifies the configuration of two Microwave Landing Systems (MLS) of different designs when installed at opposite ends of a runway. The configuration is shown in this report in Figure 1-1. All of the equipment shown in the figure is MLS equipment except for the RMMS and the Aux Data equipment. The MLS equipment of one system design is denoted by the wide solid outlines. The equipment of another MLS design is outlined with a wide cross-hatch. This report provides the interoperability specifications which address the functional and operational interface requirements for implementing this configuration.

(Note that FAA-STD-022 and FAA-E-2721 also require that all microwave landing systems support operations at both ends of the runway and that any system shall be capable of being configured for either end, i.e. any system may be assigned to either the solid outlines or to the cross-hatch outlines. In the case where one system equipment design supports operations at both ends of the runway, the interface requirements of this report are not applicable.)

Interoperability is achieved by specifying processing requirements for and communications interface requirements between the two systems. The interface shall provide the following functions:

- (a) MLS control mode and equipment state through the transmission of commands and responses;
- (b) Remote Maintenance Monitoring System (RMMS) maintenance capability through the transmission of status, data and control commands; and
- (c) Time division multiplexing (TDM) of the radiated signals-in-space through the transmission of a synchronization signal.

The communication interface shall be physically implemented between the Remote Control and Status Unit Electronics Units (REUs) of the two systems (Figure 1-1). These two REUs are joined by a data link designed in accordance with the frame and protocol requirements of NAS-MD-790 and ANSI X3.66, and in accordance with the optical fiber transmission media requirements of EIA-533. This interface shall implement the design options offered by these documents in accordance with the guidelines provided in DOT/FAA/PS-89/2 and this report.

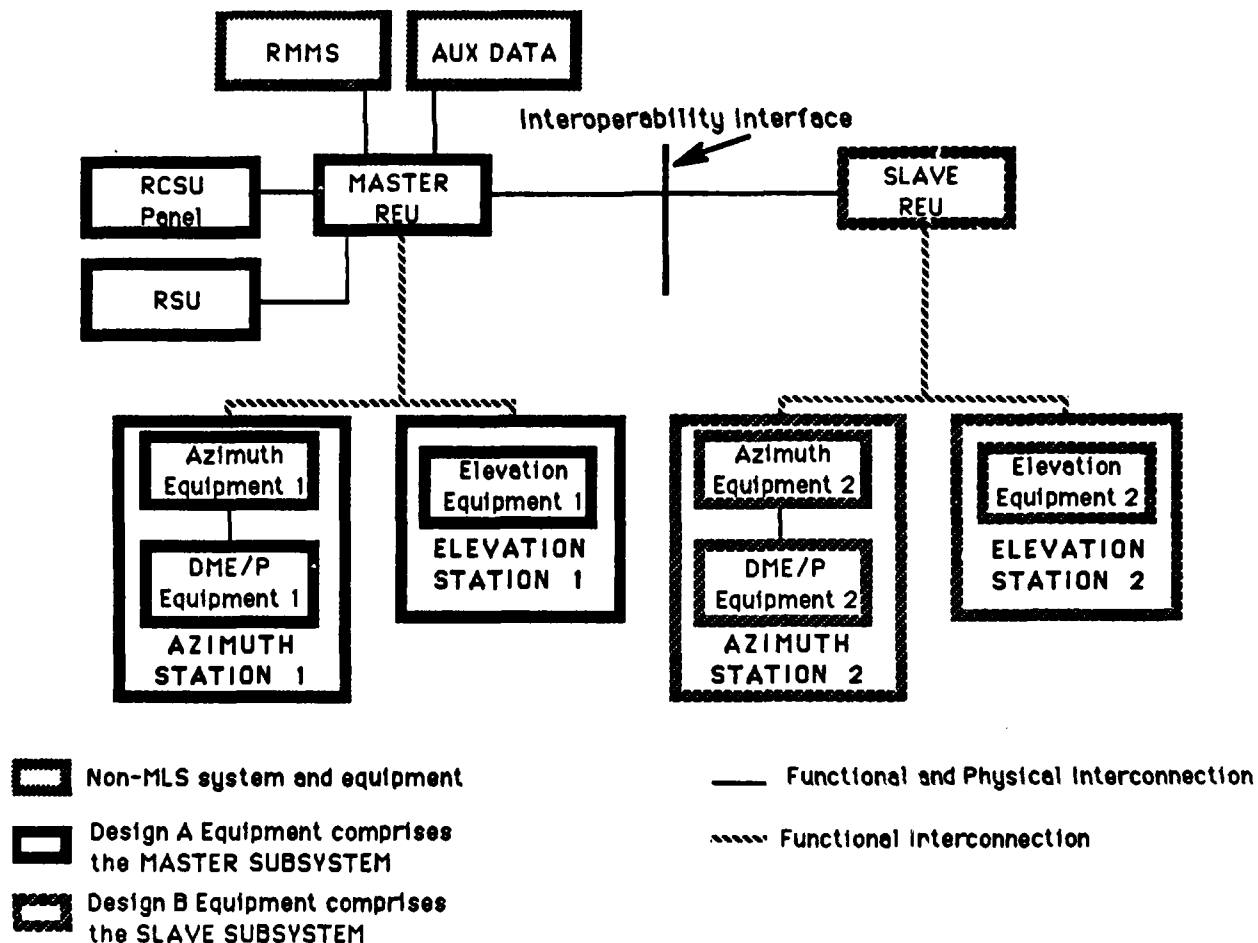


Figure 1-1. Structure of MLS Ground Equipment and Stations for Multiple Design Interoperability

1.2 Purpose of report. This document provides the interoperability criteria for the interface between two microwave landing systems of different designs when installed at the opposite ends of the runway. Interoperability shall be implemented to report the status of the MLS, to control the configuration of the MLS, and to synchronize the signals in space of the two systems. The interoperability criteria include the specifications for the electrical, optical, mechanical, functional protocol and information format interfaces between the two MLSs. This report shall be used as a guideline for preparing Interface Control Documentation that will establish the communications capability.

1.3 Scope of report. This report specifies the design criteria for a communications interface which shall permit two Microwave Landing Systems of different designs to service opposite ends of the same runway. In section 2 the functional operation of the interface is defined and the periodicity of the data transfer is specified. Section 3 defines the format of the command, message, and data which are transferred between the systems. Section 4 specifies the configuration of the data link which implements the interface, and the physical requirements for the transmission signals and media. Section 5 defines the frame formats for the data link.

1.4 Precedence. Requirements specified in this report shall not be interpreted to waive or relax any other requirements that are identified by the FAA-E-2721 series of specifications or FAA-STD-022.

1.5 Definitions.

1.5.1 Local status file. The function that stores a system's logical unit data.

1.5.2 Message buffer. The function that stores formatted messages and responses which are awaiting transmission from the REU.

1.6 Applicable documents. The following documents are referenced in this interface control report. They are applicable to the Interoperability Interface to the extent specified herein.

1.6.1 Government documents.

SPECIFICATIONS

FAA

FAA-E-2721 Microwave Landing System

STANDARDS

FAA

NAS-MD-790 Remote Maintenance Monitoring System
Interface Control Document - Maintenance
Processor Subsystem to Remote Monitoring
Subsystems and Remote Monitoring Subsystem
Concentrators

FAA-STD-022 Microwave Landing System (MLS)
Interoperability and Performance
Requirements

REPORTS

FAA

DOT/FAA/PS-89/2 Microwave Landing System Remote Monitoring
System/Remote Maintenance Monitoring
System Interface Control Report

1.6.2 Non-Government documents.

STANDARDS

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

- | | |
|-----------------|--|
| ANSI X3.4-1968 | American National Standard Code for Information Interchange (ASCII) |
| ANSI X3.16-1976 | Character Structure and Character Parity Sense for Serial-By-Bit Data Communication in the American National Standard Code for Information Interchange |
| ANSI X3.41-1974 | Code Extension Techniques for Use with the 7-Bit Coded Character Set of American National Standard Code for Information Interchange |
| ANSI X3.66-1979 | Advanced Data Communication Control Procedures (ADCCP) |

ELECTRONIC INDUSTRIES ASSOCIATION

- | | |
|---------|---|
| EIA-533 | Optical Fiber Interface That May Be Employed for Synchronous or Asynchronous, Point-to-Point Interconnection of Digital Equipment |
|---------|---|

2. FUNCTIONAL INTERFACES

2.1 General. All hardware and software which is used to implement the functional and operational requirements of the interoperability interface shall conform to all of the specifications of FAA-E-2721 and this report. This interface shall provide the means for controlling the operational status of the MLS systems, implementing the Remote Monitoring Subsystem (RMS) maintenance functions, and synchronizing the MLS signal-in-space radiations.

2.1.1 System configuration. When the MLS installation is implemented using MLSs of two different designs, one system shall be designated as the "Master Subsystem" and the other as the "Slave Subsystem". This unique designation of each MLS shall not change regardless of their equipment mode. That is, the MLS which is designated Master shall always be the master whether it is supporting approach azimuth or back azimuth operations at a particular runway installation.

2.1.1.1 Master subsystem. The Master Subsystem shall consist of the hardware and software that comprise the following equipment. (See Figures 1-1 and 2-1.)

- (a) Azimuth 1 (AZ1) Station which includes the DME/P1 equipment,
- (b) Elevation 1 (EL1) Station,
- (c) Remote Control and Status Unit (RCSU) Panel,
- (d) Remote Status Unit (RSU) which includes all RSUs associated with a particular MLS installation, and
- (e) RCSU Electronics Unit (REU).

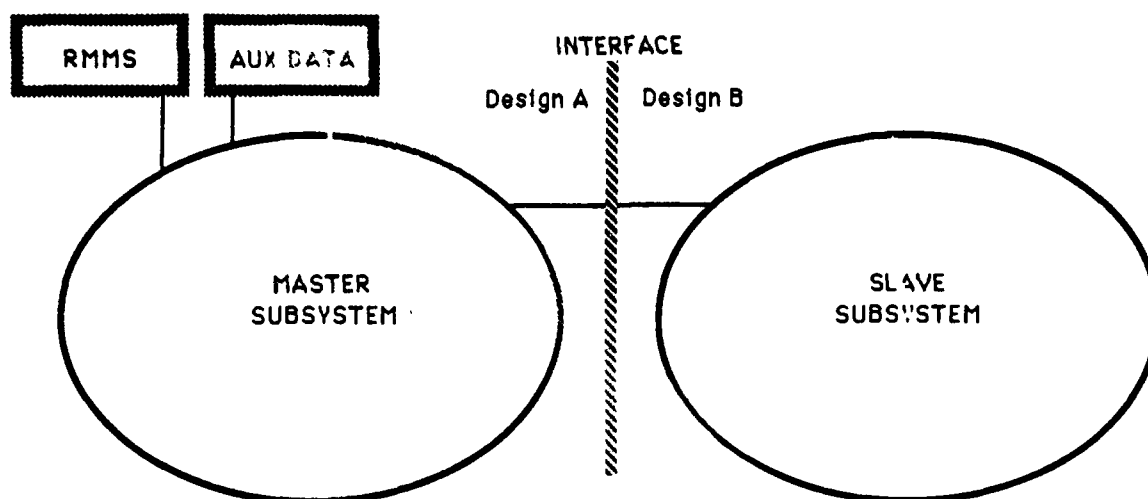
The master subsystem shall perform all functions identified in FAA-E-2721 for the above equipment including signal-in-space radiation and RMS operation. In addition, the master subsystem shall perform all functions of the interoperability interface as identified herein.

2.1.1.2 Slave subsystem. The Slave Subsystem shall consist of the hardware and software that comprise the following equipment. (See Figures 1-1 and 2-1.)

- (a) Azimuth 2 (AZ2) Station which includes the DME/P2 equipment,
- (b) Elevation 2 (EL2) Station, and
- (c) RCSU Electronics Unit (REU).

The slave subsystem shall perform all functions identified in FAA-E-2721 for the above equipment including signal-in-space radiation and RMS operation. In addition, the slave subsystem shall perform all functions of the interoperability interface as identified herein.

2.1.2 Interoperability interface communications. The operation of the interoperability interface shall be based on the MLS functional requirements, the MLS operational requirements, and the data link physical media and protocol requirements as specified herein. The interoperability interface of Figure 2-1 shall be implemented with two (2) communication channels as shown in Figure 2-2.



The MASTER SUBSYSTEM is comprised of an REU and the AZ1, DME/P1, EL1, RCSU Panel and RSU(s).

The SLAVE SUBSYSTEM is comprised of an REU and the AZ2, DME/P2, and EL2.

— Functional and Physical Interconnection

Figure 2-1. Subsystem Communication Interface for Implementing Multiple Design Interoperability

Figure 2-2 is a block diagram of the various functions that shall be transferred via this interface. The status and control channel shall provide the communications capability for controlling the operational status of the MLS systems and implementing the RMS maintenance functions. The Synchronization Channel shall provide the communications required to synchronize the MLS signal-in-space radiations.

2.2 Status and control channel requirements. This channel of the master and slave subsystem interface shall assist in achieving control of the microwave landing system and in executing RMS maintenance functions as defined in FAA-E-2721.

2.2.1 Gateway functions. Pertinent information to the operation and the maintenance of the MLS is transferred via the functions shown in Figure 2-2 in the status and control channel. The master subsystem generates and transmits commands and polls. The slave subsystem executes the commands and responds to the polls by transmitting updated information from the local status file (LSF) and message buffer.

2.2.2 Control mastership. Control mastership as defined in FAA-E-2721 shall be available at portable terminal interfaces within each subsystem and at the MPS via the RMMS interface within the master subsystem.

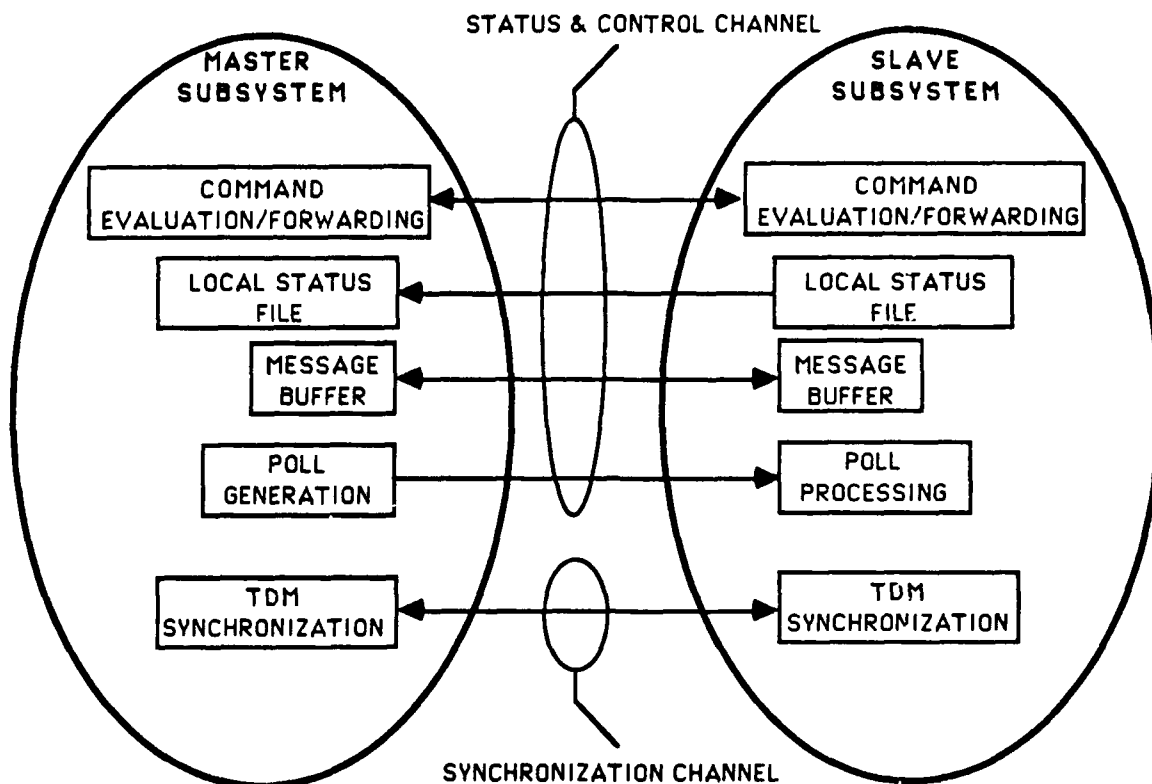


Figure 2-2. Block Diagram of the Interface Functions between the Master Subsystem and the Slave Subsystem

2.2.2.1 Control mastership requests. The subsystems shall process the following requests:

- (a) Maintenance Control
- (b) Relinquish Maintenance Control

2.2.2.2 Control mastership responses. Both subsystems shall acknowledge all requests.

2.2.2.3 Commands. Both the Master and the Slave Subsystems shall accept and process the following commands as appropriate:

- (a) Equipment On
- (b) Equipment Off
- (c) Redesignate Primary Equipment
- (d) Initiate Equipment Restart
- (e) Runway Reconfigure
- (f) RMS Password Change
- (g) Return Monitor to Normal
- (h) Initiate Monitor Bypass
- (i) Initiate End-To-End Integrity Check

- (j) RMS Reset*
- (k) Request Maintenance Control
- (l) Relinquish Maintenance Control
- (m) Initiate Manual Diagnostics

* This function when applied to the master to slave subsystem interface shall cause the slave subsystem to reset. The slave subsystem actions shall include clearing registers, resetting counters to zero, and initializing variables to starting values.

2.2.2.3.1 Command processing in the subsystems. The master subsystem and slave subsystem shall process all commands which they receive from the RMMS and from the portable terminals. The subsystem, as it receives a command, shall ascertain whether the command is viable for the microwave landing system. It shall then validate the command for the current system mode of operation. If valid, the subsystem shall commence the execution of the commands. Execution of the command shall be accomplished via one of two routes. If the command involves equipment connected to the subsystem which has been doing the evaluation, the subsystem shall direct that equipment to execute the appropriate actions. If the command involves equipment that is connected to the other subsystem, then the subsystem doing the evaluation shall forward the command to the other subsystem for evaluation and execution.

2.2.2.3.2 Command evaluation time. Each subsystem shall evaluate commands as they are received to determine which subsystem should process it (as defined in 2.2.2.3.1). The subsystem shall either commence processing the command itself or place the command in the message buffer for forwarding to the other subsystem for processing. The command evaluation time, from entry of a command into the subsystem until the subsystem either has inserted it into the message buffer for forwarding to the other subsystem or has started implementing it, shall have an average value of 250 milliseconds (ms) or less, and have a maximum value of 500 ms.

2.2.2.3.3 Command response messages. The subsystem which has received a command from the other subsystem shall transmit response messages to the sending subsystem in accordance with 2.2.6.

2.2.3 RMS maintenance capability. The interoperability interface shall be used to enable the MLS to meet its RMS requirements by providing information concerning the slave subsystem to the master subsystem for subsequent transmission to the RMMS. This information shall include measured parameter data, equipment status, RMS messages, and terminal messages. The master subsystem shall poll the slave subsystem which shall respond by sending the proper information.

2.2.3.1 Subsystem allocation of RMS functions. The master subsystem and the slave subsystem shall each store and process the MLS-related RMS data that is generated within the respective subsystem. In addition, the master subsystem shall store data originating in the slave subsystem.

2.2.3.2 Data requirements. All measured parameter values, alarm thresholds, equipment status, and terminal data associated with the master subsystem and with the slave subsystem shall be stored in a Local Status File (LSF) within the appropriate subsystem. (See Table I.) Where required by specific microwave landing system designs of the master subsystem and the slave subsystem, parameters in addition to those listed in the RMS section of FAA-E-2721 shall be stored in the LSF of the applicable subsystem. Information stored for each parameter shall be the latest measured value, or the latest filtered output, as appropriate.

In addition to this data, the Basic and Auxiliary Data Words associated with the master subsystem and the slave subsystem shall be stored in the Local Status File of that associated subsystem.

The data in the slave subsystem LSF shall be available upon request from the master subsystem (see 2.2.5 below). The interoperability interface shall be used to effect the updating of the LSF in the master subsystem with RMS related information from the slave subsystem.

Unlike the above data, the Historical Performance Records shall only be stored in the Historical Performance File of the master subsystem LSF where a minimum of the last eight data sets collected shall be stored. These data sets shall be compiled from the data in the master subsystem LSF which includes the data that originated in the slave subsystem as well as the master subsystem.

2.2.3.3 Data processing requirements. Each subsystem shall perform certain data processing operations. Table I lists these operations and the subsystem in which they are to be executed. The following paragraphs provide detailed requirements for data processing.

2.2.3.3.1 Alarm determination. Each subsystem shall determine when integrity, secondary, maintenance, and environmental parameters associated with that particular subsystem have entered an alarm condition in accordance with FAA-E-2721.

2.2.3.3.2 Return-To-Normal determination. Each subsystem shall determine that an alarm condition, which it had previously reported no longer exists.

2.2.3.3.3 Change of State determination. Each subsystem shall determine that a change has occurred to the status of the equipment which comprises that subsystem in accordance with FAA-E-2721.

2.2.3.3.4 Fault diagnostics. Each subsystem shall initiate diagnostics automatically when an integrity alarm occurs. After an alarm the diagnostics information and identification of the faulty LRU are not required to be available until after a five-minute-equipment-restart attempt has been unsuccessful. The extent of the diagnostics capability regarding identification of failed LRUs shall be in accordance with the fault diagnostics paragraph of FAA-E-2721. Each subsystem shall provide a manually-initiated diagnostics capability which shall offer more detailed information on the status of LRUs to aid the corrective and preventive maintenance process. Guidance information shall not be radiated in any mode while diagnostics are being performed on the MLS.

TABLE I.
DATA and DATA PROCESSING
FUNCTIONAL DISTRIBUTION

FUNCTION	MASTER SUBSYSTEM	SLAVE SUBSYSTEM
<u>DATA</u>		
Measured parameter values		
Integrity	Y	Y
Secondary	Y	Y
Maintenance	Y	Y
Environmental	Y	Y
Alarm thresholds	Y	Y
Equipment status	Y	Y
Terminal data and messages	Y	Y
Basic data words	Y	Y
Auxiliary data words	Y	Y
Historical performance records	Y	N
<u>DATA PROCESSING</u>		
Alarm determination	Y	Y
Return-To-Normal determination	Y	Y
Change of state determination	Y	Y
Fault diagnostics performance	Y	Y
Record of Events documentation	Y	Y
Timestamping	Y	Y
Historical performance		
records compilation	Y	N

TABLE I NOTES

A "Y" in the SUBSYSTEM Column indicates that the data or the process relevant to that subsystem shall be stored in or performed by the indicated subsystem.

A "N" in the SUBSYSTEM Column indicates that the data or the process relevant to that subsystem shall not be stored in or performed by the indicated subsystem.

2.2.3.3.5 Record of Events. The master subsystem and the slave subsystem shall store in their Local Status Files the following information which is pertinent to their individual subsystems:

- (a) out-of-tolerance parameters,
- (b) state changes,
- (c) fault diagnostics results, and
- (d) time and date of each event.

Each subsystem shall store the latest 10 integrity alarms and secondary alerts, 10 maintenance warnings, 10 state changes and 10 fault diagnostic results originating from within itself. Events that occur while an MLS equipment is under maintenance control shall not be stored.

The master subsystem shall process the record of events data in both subsystems and shall store the latest 10 integrity alarms and secondary alerts, 10 maintenance warnings, 10 state changes and 10 fault diagnostic results as they apply to the entire MLS for subsequent transmission to the RMMS.

2.2.3.3.6 Timestamping. Each subsystem shall maintain a real time clock as specified in FAA-E-2721 to provide a digital output containing the year, month, day, hour, minute and second to facilitate timestamping of events.

2.2.3.3.7 Historical Performance Records. The master subsystem shall collect the integrity, secondary and maintenance parameters, and status once every eight hours from both subsystems. It shall store a minimum of the last eight data sets collected.

2.2.4 Message requirements. The interoperability interface shall be used to effect the updating of the Message Buffer in the master subsystem with RMS messages and terminal messages from the slave subsystem.

The master subsystem and the slave subsystem shall each prepare messages relevant to their respective operations and insert these messages into their own message buffers. These messages shall not be prepared when the MLS equipment is under maintenance control.

2.2.4.1 RMS messages. The following RMS related messages shall be generated:

- (a) Alarm message
- (b) Return-To-Normal message
- (c) State Change message

2.2.4.2 Terminal messages. The master subsystem and the slave subsystem shall each store in their respective message buffers those messages which were generated at a portable terminal.

2.2.4.3 Message priority. Each subsystem shall prioritize the messages which they individually generate in the order listed below. The priority shall establish the order in which the messages are transmitted in response to a poll. Multiple messages within each message category (e.g. two or more secondary alerts) shall be scheduled for transmission in order of their occurrence (first in, first out basis).

- (a) Alarm Messages:
 - (1) Integrity Alarms
 - (2) Secondary Alerts
 - (3) Maintenance Warnings
- (b) Return-To-Normal Messages
- (c) State Change Messages
- (d) Terminal Messages

The slave subsystem shall provide messages in its buffer to the master subsystem upon request. The master subsystem shall combine the messages it receives from the slave subsystem with those that it generates and prioritize the combination in accordance with the above list.

2.2.5 Polling. The master subsystem shall poll and the slave subsystem shall respond to being polled.

2.2.5.1 Data sampling polls. The master subsystem shall poll the slave subsystem for integrity parameters and update the master subsystem LSF at least once every 3 (three) seconds. The master subsystem shall sample the secondary parameters, maintenance parameters, non-essential auxiliary data words, environmental parameters, and equipment status of the slave subsystem at an average sampling time of 25 seconds. In no case shall the sampling time for any parameter exceed 2 (two) minutes.

2.2.5.2 Message sampling polls. The master subsystem shall poll the slave subsystem message buffer within an average rate of once every 1.0 (one) second and within a minimum rate of once every 5 seconds.

2.2.5.3 Sampling processing time. The subsystems shall process the polls and the data that they receive from the other subsystem in accordance with the following timing criteria. The slave subsystem shall begin transmitting the requested data or messages within an average time of 500 ms and a maximum of 3 (three) seconds after receipt of the poll. The master subsystem shall commence entering the data and messages into its LSF and message buffer within an average time of 250 ms and maximum of 1 (one) second after it begins receiving them.

2.2.6 Responses. The receiving subsystem shall return a response to the sending subsystem upon receipt of a transmission which includes commands, RMS maintenance information, terminal messages and polling requests.

2.2.6.1 Acknowledge response. The receiving subsystem shall transmit an acknowledge response within an average time of 250 ms and a maximum time of 500 ms after receipt of the transmission.

2.2.6.2 Busy status response. The receiving subsystem shall transmit a busy-status response back to the sending subsystem when it is not ready to receive a transmission or to respond to commands. The busy-status response shall be transmitted within an average time of 250 ms and a maximum of 500 ms from the time it receives the transmissions.

2.2.6.3 Error response. The subsystem shall respond with an error response when it cannot interpret transmissions within an average time of 250 ms and a maximum of 500 ms from the time it receives the transmissions.

2.3 Synchronization channel. - This channel of the interoperability interface shall assist in the performance of MLS signal-in-space radiations.

2.3.1 Gateway functions. The time-coordination functions required for the proper operation and maintenance of the MLS are carried by the Synchronization Channel. The subsystem which is performing the approach azimuth function shall transmit a timing message to the other subsystem. This subsystem shall process the timing message to enable it to synchronize the back azimuth signal-in-space radiations with the approach azimuth radiations. (See figure 2-3.)

2.3.2 Timing message. The timing message shall consist of a digital bit stream. One of the bits of the message shall be synchronized with the commencement of the synchronization cycle as defined in FAA-E-2721.

2.3.3 Repetition rate. The subsystem providing the approach azimuth function shall transmit the timing message within 1 (one) ms of the start of each synchronization cycle.

2.3.4 Non-occurrence. If the timing message fails to arrive at the receiving subsystem or if it is invalid, the subsystem shall continue to transmit signals-in-space based on its internal clock for up to two minutes in accordance with 2721. In addition, it shall continue to monitor for the arrival of a valid timing message.

2.3.5 Delay compensation. The subsystem receiving the message shall compensate for the delay induced during the processing of the command.

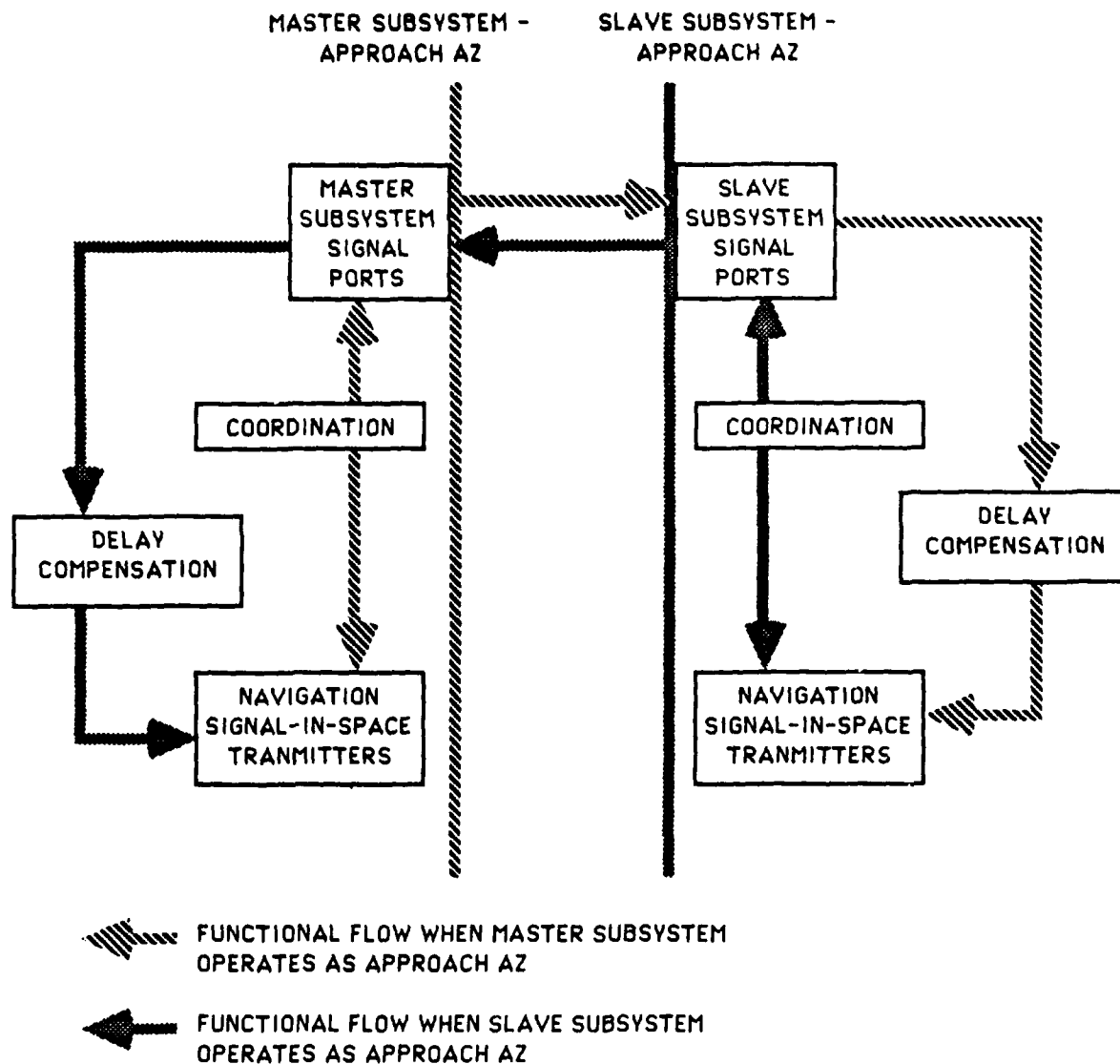


Figure 2-3. TDM Synchronization Interface Locations

3. SYSTEM OPERATIONAL REQUIREMENTS.

The interoperability interface shall be implemented with two (2) communication channels (Figure 2-2). The following criteria defines the formats for the data, messages, commands and polls which are transmitted via these channels.

3.1 Status and control channel. The master system is designated as the primary station and shall control the sequence of command and data interchange within the status and control channel of the interoperability interface.

The slave subsystem shall be designated as a separately addressed secondary station and shall perform communication functions as directed by the primary station, including:

- (a) Accepting data (commands and messages) from the primary station
- (b) Sending data, status, or other RMS related information to the primary station, upon request
- (c) Executing commands received from the primary station.

3.1.1 Logical unit addressing. All of the master subsystem and slave subsystem data shall be grouped into separately addressable logical units as defined by DOT/FAA/PS-89/2.

3.1.2 Poll and response. The interoperability interface shall transfer data, messages, and commands in accordance with a polling technique. The master subsystem shall transmit three different types of polls over the data link to request that the slave subsystem transmit its information. These are Continuous Polls, Scheduled Polls, and Specific Polls. The slave subsystem shall comply by transmitting the information as follows:

3.1.2.1 Response to the continuous poll. The slave subsystem shall send all messages waiting in the message buffer, in order of their priority (see 2.2.4.3).

3.1.2.2 Response to the specific poll. The slave subsystem shall send a single Site Data Report for the logical unit addressed by the poll. A Site Data Report (SDR) provides values for all data points in a single logical unit.

3.1.2.3 Response to the scheduled poll. The slave subsystem shall send a Site Data Report for each of the following logical units which are defined by DOT/FAA/PS-89/2.

- (a) RMS Master (equipment status)
- (b) Integrity and Secondary Parameters
- (c) Maintenance Parameters
- (d) Environmental Parameters

3.1.2.4 Response precedence for specific and scheduled polls. Messages waiting in the message buffer upon receipt of a specific or scheduled poll shall be sent prior to response for the poll. If a message is generated during a specific or scheduled poll response, the message shall be transmitted after the logical unit currently being transmitted completes transmission.

3.1.3 Poll format.

3.1.3.1 Continuous poll. The frame format for the continuous poll shall be as shown in DOT/FAA/PS-89/2.

3.1.3.2 Specific poll. The frame format for the specific poll shall be as shown in DOT/FAA/PS-89/2.

3.1.3.3 Scheduled poll. The frame format for the scheduled poll shall be as shown in DOT/FAA/PS-89/2.

3.1.4 Poll response format. The function code, the message data and, when applicable, the condition status code for the following messages and data reports shall comply with the Poll Response Information requirements of DOT/FAA/PS-89/2:

- (a) Alarm message
- (b) Return-To-Normal (RTN) message
- (c) State change message
- (d) Terminal message
- (e) Site data report

3.1.5 Command format. The function code and the message data (command codes, equipment codes, and user identifiers) for the following commands shall comply with the command requirements of DOT/FAA/PS-89/2:

- (a) Equipment On
- (b) Equipment Off
- (c) Redesignate Primary Equipment
- (d) Initiate Equipment Restart
- (e) Runway Reconfigure
- (f) RMS Password Change
- (g) Return Monitor to Normal
- (h) Initiate Monitor Bypass
- (i) Initiate End-To-End Integrity Check
- (j) RMS Reset
- (k) Request Maintenance Control
- (l) Relinquish Maintenance Control
- (m) Initiate Manual Diagnostics

3.1.6 Data encoding. Numeric Data and the Character Set shall be encoded in accordance with DOT/FAA/PS-89/2.

3.2 Synchronization channel. The master system and the slave subsystems shall control command transmission, command processing, and recovery operations within the synchronization channel of the interoperability interface.

3.2.1 Primary and secondary communication stations. The primary station shall transmit the command sequence which provides the synchronization pulse (refer to 4.3.2). The secondary station shall accept the synchronization command, evaluate it for accuracy, process it to synchronize signal-in-space transmissions, and provide protection from the non-recognition of the end of the command.

3.2.2 Reconfigurable stations. Reception by the stations of the "Runway Reconfigure" command over the status and control channel shall reverse the primary and secondary roles of the master and slave subsystems.

3.2.3 Command format. The synchronization command shall consist of a receiving equipment identifier, a timing pulse, and a means to detect transmission errors.

3.2.3.1 Identification. The synchronization command shall identify the azimuth station that is operating as the back azimuth (i.e. address of the station receiving the synchronization signal). The identifier shall be the standard equipment coding: hexadecimal "01" for Azimuth 1, and hexadecimal "02" for Azimuth 2 as defined in DOT/FAA/PS-89/2.

3.2.3.2 Synchronization event. The synchronization event in the command shall be the bit sequence that in the status and control channel is the SNRM command. The binary sequence of this event is:

1 1 0 0 P 0 0 1.

Where "P" equals "1". In the SNRM command, it is interpreted as the "poll" bit indicating a command and establishes the requirement for a response. In this channel, however, the P = 1 shall not require such a response. The transmission of the trailing edge of the "P" bit onto the interoperability interface data link shall coincide with the beginning of the transmission sequence (zero cumulative time) as specified in FAA-E-2721.

3.2.3.3 Transmission validation. The secondary station shall monitor the frame check sequence (FCS). If an FCS error occurs, the station shall not accept the frame and shall continue to transmit back azimuth signals based on its internal clock within the time out limitations specified in FAA-E-2721 regarding the loss of the synchronization signal. Upon receiving the next command, the secondary station shall evaluate it, and if valid, use it to synchronize its next signal-in-space transmission. The operation of the FCS shall be in accordance with the frame check sequence generation and checking section of ANSI X3.66-1979 (ADCCP).

3.2.4 Command delay compensation. The secondary station shall compensate for the processing delays that the command incurs after it is received. The compensation shall enable the subsystem associated with the secondary station to maintain synchronization with the approach azimuth transmission sequence within the specified tolerances of FAA-E-2721. (The propagation time for the command to transverse the length of the data link shall be considered to be zero since the link distances will be negligible.)

3.2.5 Recovery. The secondary station shall monitor the command to protect against non-recognition of the end of the command. If the end of the command is not identified, this particular transmission of the command shall be discarded.

4. PHYSICAL INTERFACES FOR INTEROPERABILITY IMPLEMENTATION.

The interoperability of two MLSs of different designs shall be implemented via a communications interface. This interface shall be a point-to-point data link established between the RCSU Electronics Units (REUs) of the Master and the Slave microwave landing systems.

4.1 REU capabilities. A single REU shall be configured or reconfigurable to support each of the three MLS configurations required by FAA-E-2721. It shall be capable of performing as the REU associated with the master subsystem or the slave subsystem in 2.1.1 above. In addition, it shall be capable of performing the functions of the standalone REU in the MLS configuration where both runway ends have MLS equipment consisting of hardware and software of all one design.

4.1.1 Master REU. When the REU is part of the master subsystem, it shall be identified as the Master REU and shall provide the functional capabilities required by FAA-E-2721 for all REUs as well as the functional capabilities for the master subsystem as defined herein.

4.1.2 Slave REU. When the REU is part of the slave subsystem, it shall be identified as the Slave REU and shall provide the functional capabilities required by FAA-E-2721 for all REUs and required by this report for Slave applications.

4.1.3 Standalone REU. When the REU is installed in an MLS configuration which consists of hardware and software of only one design, it shall be identified as a Standalone REU. It shall have the capability to perform all functions as identified in FAA-E-2721 without dependence on the interoperability interface specified in this report.

4.2 Status and control channel data link control. The channel shall connect to each REU and shall function in the unbalanced, two-way simultaneous configuration as defined in ANSI X3.66 (ADCCP). (See Figure 4-1.)

4.2.1 Channel configuration. The master subsystem shall perform the functions of the ADCCP primary station and the slave subsystem shall perform the functions of the ADCCP secondary station for the Status and Control Channel. The assignment of the primary station functions to the master subsystem and the secondary station functions to the slave subsystem shall not change regardless of the operating configuration of the MLS. That is, this primary and secondary station assignment is independent of which azimuth station (AZ1 or AZ2) is configured as the approach azimuth.

4.2.2 Channel data rate. The data rate shall be 9600 bits per second (bps).

4.2.3 Transmission and reception points. The point of transmission shall be at the channel optical port of the transmitting subsystem (see 4.4). The point of reception shall be at the channel optical port of the receiving subsystem.

4.3 Synchronization channel data link control. The channel shall connect to each REU and shall consist of two, one-way channels. (Figure 4-1). The channel shall function in an unbalanced, one-way configuration similar to the two-way alternate configuration defined in ANSI X3.66 (ADCCP) with the

following exceptions. The secondary station shall not transmit a response to the primary station. The primary station shall transmit only one digital bit stream which shall provide the synchronization event. However, the channel shall be a two-way channel since the master and slave subsystems shall be reconfigurable. (See 4.3.2.)

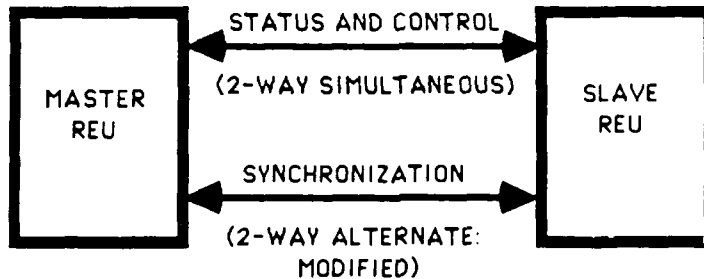


Figure 4-1. MLS Communication Channels

4.3.1 Channel configuration. The master subsystem shall function as the ADCCP primary station while the slave subsystem functions as the ADCCP secondary station. Alternatively, the slave subsystem shall function as the primary station while the master subsystem functions as the secondary station. The subsystem which is providing the approach azimuth guidance shall function as the primary station; while, the other subsystem which is providing the back azimuth guidance shall function as the secondary station.

4.3.2 Subsystem reconfiguration. The master and slave subsystems shall be capable of being reconfigured in accordance with ANSI X3.66-1979: As a result of mode-setting action, each subsystem shall be, at different times, more than one type of logical station (see 3.2.2). When the azimuth station in the master subsystem (AZ1, see Figure 1-1) is designated as the approach azimuth, the master subsystem shall be the primary station and shall transmit the synchronization signal to the slave subsystem (secondary station). Alternately, when the azimuth station in the slave subsystem (AZ2) is designated as the approach azimuth, the slave subsystem shall be the primary station and shall transmit the synchronization signal to the master subsystem (secondary station).

4.3.3 Channel data rate. The data rate shall be 9600 bits per second (bps).

4.3.4 Transmission and reception points. The point of transmission for the synchronization event as specified in 3.2.3.2 shall be at the channel optical port of the transmitting subsystem, i.e. the port of the primary station. (See 4.4). The point of reception of the synchronization event shall be at the channel optical port of the receiving subsystem, i.e. the port of the secondary station.

4.4 Physical transmission link. Each of the two channels of the interoperability interface shall be implemented via two (2) optical fiber, point-to-point data links. The physical interfaces with the REU of each subsystem shall be in accordance with EIA-533. Each data link shall operate synchronously and shall have the following characteristics.

4.4.1 Information characteristics. The character structure shall be in accordance with ANSI X3.16-1976 using the seven-bit character structure with odd parity based on ANSI X3.4-1968 and extended by ANSI X3.41-1974. The data link shall be synchronous with data signaling and modulation rates of 9600 bps.

4.4.2 Optical characteristics.

4.4.2.1 Optical operating wavelength. The data link shall operate at a nominal 820 nanometers (nm) with a half power line width of 50 nm.

4.4.2.2 Optical power levels. The optical power requirements shall be "power inserted" into and out of the optical fiber.

4.4.2.2.1 Transmitter. The transmitter shall comply with the following optical power requirements.

The optical ON signal shall have the following characteristics:

- (a) Maximum equals 30 microwatts (uW) (-15.2 dBm)
- (b) Minimum equals 7.2 uW (-21.3 dBm)
- (c) Maximum positive or negative optical power transient equals 10 percent of nominal power level for 10 ns.

The optical OFF signal shall have the following characteristics:

- (a) Maximum equals 30 nanowatts (nW) (-45 dBm)
- (b) Maximum positive or negative optical power transient equals 100 nW (-40 dBm) for 10 ns.

4.4.2.2.2 Receiver. The receiver shall comply with the following optical power requirements.

- (a) Minimum optical power for a binary optical ON signal equals 720 nW (-31.4 dBm)
- (b) Maximum tolerated optical power for binary optical ON signal equals 30 uW (-15.2 dBm)
- (c) Maximum tolerated optical power for binary optical OFF signal equals 100 nW (-40 dBm)
- (d) Minimum transient insensitivity equals 10 percent of nominal power level for less than 10 ns duration.

4.4.2.3 Testing. The fiber that shall be used to validate the optical power level requirements shall be multimode, and have a core diameter of 50 ± 3 micrometers (μm), a cladding diameter of $125 \pm 3 \mu\text{m}$, and a numerical aperture of 0.2 ± 0.015 .

4.4.3 Mechanical characteristics. The data link mechanical interface to the REUs of each subsystem shall use optical fiber connectors type SMA-905 which terminate 50/125 μm , multimode optical fiber. The connectors installed on the REUs shall be female jacks and shall be compatible with stainless steel male plugs. One connector shall be provided on the REU for each communication channel direction for a total of four (4) connectors.

5. BIT ORIENTED DATA CONTROL LINK PROCEDURES FOR SYNCHRONOUS COMMUNICATIONS.

The interoperability interface shall comply with the American National Standard for Advanced Data Communication Control Procedures (ADCCP - ANSI X3.66). The data link shall implement the features of the standard as enhanced and modified by this report. The basic operation shall be Normal Response Mode (NRM). The bit-oriented data link protocol shall comply with the requirements for the unbalanced, normal response mode (UN) class. All transmissions between the master subsystem and the slave subsystem shall be in frames. The frame structure for this channel shall comply with the frame structure requirements of DOT/FAA/PS-89/2 with the exceptions noted herein. The basic address format of ANSI X3.66 shall be supported; therefore, no restrictions on the first bit of the address sequence is applicable.

5.1 Status and control channel. The interface shall operate as a two way simultaneous (TWS) data link. Bit oriented data link procedures for this channel shall comply with the requirements of DOT/FAA/PS-89/2. Application of DOT/FAA/PS-89/2 to this channel shall be implemented by interpreting a reference to the MPS as a reference to the master subsystem and interpreting a reference to the RMS as a reference to the slave subsystem. The address field transmitted by both the master and slave subsystems shall be hexadecimal "02".

5.2 Synchronization channel.

The interface shall operate as a two way alternate data link with the exception that a response from the secondary station shall not be required nor transmitted. No retry procedures shall be utilized.

5.2.1 Frame structure. The frame shall consist of five elements: flag, address, control, frame check sequence, and flag (see Table II).

TABLE II. SYNCHRONIZATION CHANNEL FRAME STRUCTURE

<u>Configuration</u>	<u>Flag</u>	<u>Address</u>	<u>Control</u>	<u>FCS</u>	<u>Flag</u>
AZ1 Primary/ AZ2 Secondary	01111110	02H	SNRM	Note A	01111110
AZ2 Primary/ AZ1 Secondary	01111110	01H	SNRM	Note A	01111110

Note A: The FCS shall conform to the requirements of
ANSI X3.66-1979 (ADCCP)

5.2.2 Recovery procedures. The interoperability interface shall successfully recover following the detection or occurrence of a situation that may occur as the result of transmission errors, station malfunction, or operational conditions. A Completed Frame Counter shall reset on receipt of a start frame flag and incremented as each byte is received. If this counter exceeds a count of six (6), the frame shall be discarded.